

November 8, 2012

VIA ELECTRONIC MAIL AND ECFS

Ms. Julie Veach
Chief, Wireline Competition Bureau
Federal Communications Commission
445 12th Street, SW
Washington, D.C., 20554

**Re: Toll-free Number Exhaust Forecasting/ 844 Numbering Plan Area
Recommendation, CC Docket No. 95-155, and WCB Docket 12-260**

Dear Ms. Veach:

On June 27th of this year, SMS/800, Inc. (“Company”) notified the Commission of its April 2012 forecasting assessment of the utilization of toll-free numbers (“April 2012 Forecast”) and the need to prepare the SMS/800 to support the addition of the 844 Number Plan Area (“NPA”). The April 2012 Forecast included a forecast exhaust of existing toll-free number resources then in service and available to the public. That letter and study was also filed in CC Docket No. 95-155.¹

On October 16th of this year, Company management and outside counsel met with the Commission in order to, in part, further discuss the status of existing toll-free number resources and the criteria for exhaust.² In that meeting the Company informed the Commission that it was in the process of having an updated toll-free number utilization assessment prepared (“October 2012 Forecast”). The Commission requested that, based on the October 2012 Forecast findings, the Company provide a recommendation regarding the provision of notice to the industry to prepare for the 844 NPA code opening for toll-free numbers.

¹ <http://apps.fcc.gov/ecfs/document/view?id=7021980834>

² <http://apps.fcc.gov/ecfs/document/view?id=7022036467>

Therefore, this letter sets out the findings of the October 2012 Forecast, attached hereto as Exhibit A, and SMS/800's recommendation.

As noted in the October 2012 Forecast, as of September 29, 2012, 33.16 million toll-free numbers were in use. This number equates to roughly 83% of the total pool available. Further, as the table shows below, the study forecasts the calendar periods during which toll-free numbers in use are forecast to surpass 85%, 90% and 95% of the current toll-free number pool available. Finally, the study's meta-model forecasts exhaust of the currently available toll-free number pool during the fourth quarter of 2015. This conclusion is similar to the exhaust date estimated in the April 2012 Forecast and our letter of June 27, 2012.

Percentage of Toll-free Numbers in Spare Pool	Percentage of Toll-free Numbers In Use	Toll-free Numbers in Use	Period When Reached
15%	85%	33,821,578	2013Q1
10%	90%	35,811,083	2014Q1
5%	95%	37,800,587	2015Q1
0%	100%	39,790,093	2015Q4

The statistical techniques used to develop these projections rely on historical data and thus cannot predict turning points or dramatic changes in growth that are not implicit in the historical data. For example, the April 2012 Forecast and October 2012 Forecast make no predications of economic expansion or contraction that, naturally, could affect commercial demand for toll-free number resources. Thus, the forecasting exercise simply describes the most likely date that toll-free number capacity will be reached if the data patterns of the study period, August 1997 through September 2012, should continue into the future. The Company believes this is a reasonable and robust approach and supports the findings.

Accordingly, the Company strongly recommends that the industry be notified that the 90% in-use criteria for existing toll-free number resources will occur in the first calendar quarter of 2014, with full exhaust in the fourth calendar quarter of 2015. This recommendation is made in consideration of, and well in anticipation of, the thirty months to exhaust industry notification timeframe and the twenty-seven month Public Letter notification procedures for the North American Numbering Plan Administrator as specified in industry standard guidelines.³

³ ATIS-0300057, Toll Free Resource Exhaust Relief Planning Guidelines, July 1998

A copy of this letter and attachment is being filed concurrently in CC Docket 95-155 and WCB Docket 12-260.

Sincerely,



Thomas O. FitzGerald
President and Chief Executive Officer
SMS/800, Inc.

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Exhibit A



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Forecasting Utilization of Toll-Free Numbers

SMS/800, Inc.

October 2012

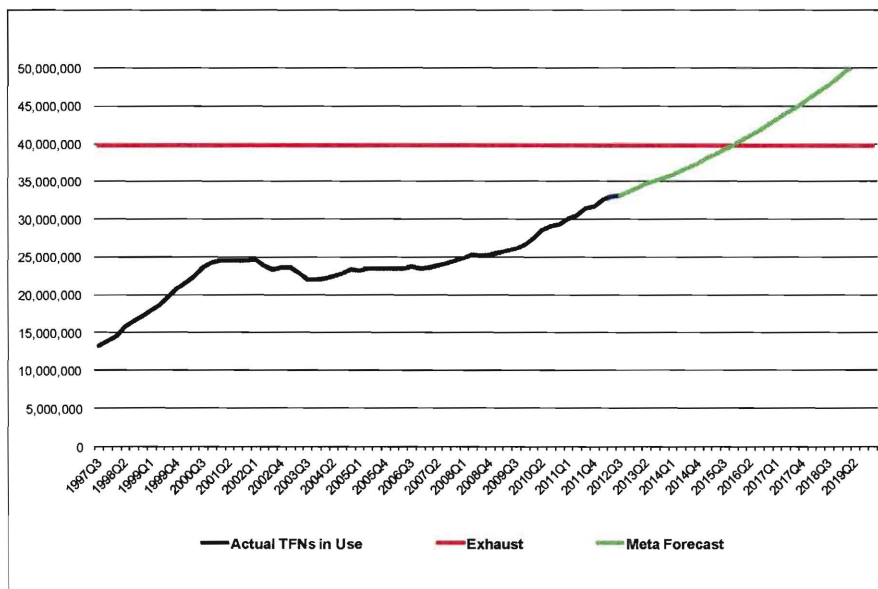
Executive Summary

The business decision facing SMS/800 is when to start the planning and development effort required to open a new toll-free Numbering Plan Area (NPA). Pursuant to ATIS guidelines¹, that planning begins with an announcement to the industry when the forecasted exhaust date for the existing toll-free number (TFN) pool is within 30 months. However, as a responsible steward of the TFN pool, SMS/800 has used a conservative approach, choosing to announce the new NPA earlier than required when it anticipates that up to 90% of the TFN pool will be in use. The balance sought is to allow the industry an appropriate amount of time to plan for a new code opening while avoiding any substantive risk that the TFN pool might exhaust prior to the intended opening.

This announcement process requires that SMS/800 anticipate the industry's usage of TFNs more than 30 months in the future. To inform this process, SMS/800 employs statistical forecasting. In this report, a variety of candidate statistical models are considered using an approach comparable to that employed in previous studies, the most recent in April 2012. Relying on the entire historical sample, statistical models estimate exhaust in early 2018. Models relying on a truncated sample have similar statistical reliability but predict much earlier exhaust dates – as early as late 2014. As in past studies that have encountered disparate results, models are combined to form a “meta-model” that has statistical properties superior to any individual model. The choice of the meta-model is consistent with conservative, but statistically supported, decision-making with respect to planning for the next code opening. The meta-model's TFN forecast (in green) is shown below along with the historical trend of TFNs in Use and the TFN exhaust value (in red)²

¹ ATIS-0300057

² The quantity of TFNs in the pool has changed over time, but for simplicity of this graph, the exhaust line reflects only the current quantity of TFNs in the pool.



On September 29, 2012, 33.16 million TFNs were in use, roughly 83% of the TFN pool. The following table shows the period during which TFNs in Use is forecast to surpass 85%, 90% and 95% of the current TFN pool. The meta-model forecasts exhaust of the currently available TFN pool during the fourth quarter of 2015, similar to the exhaust date estimated in the April 2012 TFN analysis.

Spare % of TFN Pool	% of TFNs Remaining in Pool	TFNs in Use	Period When Reached
15%	85%	33,821,578	2013Q1
10%	90%	35,811,083	2014Q1
5%	95%	37,800,587	2015Q1
0%	100%	39,790,093	2015Q4

Although forecasting an exhaust date is helpful in determining when SMS/800 should announce a new code, it does not adequately convey the degree of risk and uncertainty (whether large or small and inherent in any forecast) as to when exhaust may occur. Forecast risk occurs because historical data demonstrate that the growth in TFNs is variable. At times, usage can accelerate quickly, as occurred during late 2009 and early

2010; at other times usage can decelerate or even decline as occurred in 2000-2003. While the forecast provides the most likely exhaust date, the forecast risk warns that history has demonstrated that the possibility of earlier exhaust is clearly not negligible. Thus, SMS/800's forecast methodology also assesses the risk of exhaust at particular dates in the near future. Of the models included in the meta-model, the more aggressive model (earlier exhaust date) indicates that the risk of exhausting the current pool of TFNs is less than 10% through the second quarter of 2014 but rises rapidly over the following three months to nearly 44% by the end of the third quarter 2014.

Based on the forecasts of the meta-model, TFN usage will reach the 90% threshold during the first quarter of 2014. Even if SMS/800 were to rely on the least aggressive growth forecast that is statistically valid, TFNs in use would reach the 90% of exhaust level in the second quarter 2015.

The statistical techniques used to develop these projections rely on historical data and thus cannot predict turning points or dramatic changes in growth that are not implicit in the historical data. Thus, the forecasting exercise that SMS/800 has performed simply describes the most likely date that toll-free number capacity will be reached *if the data patterns of August 1997 through September 2012 should continue into the future.*³

³ Time series techniques model only patterns of motion in the data and cannot account for changes in underlying external forces. If forces underlying the motion of the series change, then time series techniques must change models to adapt to new patterns in the data.

Introduction

The toll-free industry has a limited supply of toll-free numbers (TFNs). There are currently five open Numbering Plan Areas (NPAs): 800, 866, 877, 888, and 855 resulting in a total of 39,790,094 TFNs. As of September 29, 2012, 33,163,497, or 83.35%, of the available TFN pool were in use, leaving 6,626,597 TFNs in the spare pool. SMS/800 is required to announce the opening of a new NPA code 30 months in advance of the exhaust of existing TFNs. Accordingly, SMS/800 has an ongoing forecast effort to assess when, or even if, the available TFN number pool will exhaust.

Prior to the first quarter of 2008, the method used to assess when toll-free number capacity would exhaust was to divide the quantity of spare numbers by the most recent six-week rolling average of weekly TFN growth. This approach produced weekly results that were highly volatile. In the first few months of 2008, this method produced exhaust dates that differed by more than two centuries, varying from October 2009 (Weekly Number Administration report of February 29, 2008) to December 2217 (Weekly Number Administration report of January 12, 2008). Clearly, this method produced results that fluctuated significantly, sometimes substantially, each time the forecast was performed. This was not conducive to making sound business decisions. In particular, these fluctuations made it difficult to prepare for the opening of the next toll-free NPA, for which a substantial lead-time is required. Hence, to adequately plan for this eventuality, a more stable long-run forecast was needed.

The objective of the current forecast method is to produce a TFN forecast that:

- (a) does not fluctuate substantially with relatively minor changes in recent values of toll-free number usage;
- (b) reflects the uncertainty inherent to any forecast by including a range of results and an evaluation of risk of exhaust over time;
- (c) is based on long-term historical patterns in toll-free number usage rather than short-term perturbations; and,
- (d) is generated by a defensible, empirical methodology.

After examining alternative forecasting methodologies, including econometric models, SMS/800, in April 2008, adopted a purely statistical time-series forecasting approach.

This approach relies on past values of toll-free number use and captures changes in the rate of increase over time. It generates toll-free number forecasts as well as measures of the uncertainty surrounding these forecasts at particular decision dates in the future. Rather than relying on a single statistical model, this approach considers multiple statistical models from which the best models are selected.

The TFN forecast performed in October 2012 is consistent with, and builds upon, the work performed in previous TFN forecasts.

Forecasting Approach and Basic Methodology

As the steward of the TFN pool, SMS/800 has a responsibility to ensure that its customers, telecommunications carriers and the toll-free subscriber community have timely access to sufficient quantities of toll-free numbers (TFNs). One of SMS/800's most important responsibilities is to alert the telecom industry of any impending exhaust of the TFN pool. Current industry guidelines suggest that SMS/800 notify the OBF SNAC when exhaust of the TFN pool is expected to occur within 30 months. With a preponderance of caution, SMS/800's recent approach has been to notify the OBF SNAC when the quantity of TFNs in use will reach 90% of the available pool within 30 months. The specified lead time for this announcement is very important to the design of the forecasting methodology as it ties the forecast outcomes directly to SMS/800's critical business decision. The lead-time of 30 months dictates the methodology's forecast horizon at which forecasts must be sufficiently reliable to inform and aid SMS/800's business decision.

SMS/800's approach could rely on a strictly new analysis and assume a clean slate each time a TFN forecast is undertaken. This clean slate approach would examine a wide range of statistical and econometric forecasting techniques, would require significantly more calendar and staff time, and would be much more expensive. However, SMS/800 relies on its experience, both in general and specific to TFN forecasts, to focus the TFN

forecasting effort on the techniques and methods that will be most effective. For these reasons, SMS/800's current efforts did not specifically attempt to employ economic data or econometric approaches to forecasting TFNs.

SMS/800's approach follows the data. The behavior of the TFN data did not change radically since the last TFN forecast in April 2012, and thus the approach does not change radically, incorporating all that SMS/800 has learned about this data set over the last several years. As with recent work in TFN forecasting, success in using ARIMA models leads SMS/800 to again consider these models for forecasting TFNs.⁴ In addition, past analyses have also explored the application of various types of time trend regressions and Autoregressive Conditional Heteroskedasticity (ARCH/GARCH) modeling techniques, the latter of which may be useful to address fluctuations in the variance in the error terms that tend to arise with the use of longer sample periods. SMS/800 considered the time-trend regressions and ARCH/GARCH techniques as well as the use of full and truncated samples of historical data.⁵

It should be noted that statistical time-series methods, while generally sound and defensible, essentially assume that past behavior is a window into the future. They implicitly assume that TFN usage will exhibit essentially the same behavior in the future as it has over the historical period used to estimate the model. If historical TFN usage has increased rapidly, then the forecast should show continued rapid growth. Alternatively, if historical TFN growth has been gradual, then forecasted TFN growth should generally exhibit the same behavior. These statistical techniques are designed to

⁴ A time series forecasting technique such as ARIMA relies on observations of data at regular time intervals. For the sake of discussion, the illustration in this footnote uses "month" as the time interval of observation. An ARIMA model, summarized by ARIMA (p,d,q), can be characterized by three categories of parameters: **p**, the longest number of months by which past data directly influence current data, also referred to as the autoregressive (AR) term; **d**, the number of times the series (i.e. TFN) is differenced to recognize the degree of increase or decrease over time; and **q**, the longest number of months by which lagged forecast errors improve the prediction of current data. The lagged forecast error **q** term is also referred to as a "moving average" (MA) term; this term is akin to creating an exponentially weighted average of past data (of TFN or its degree of increase or decrease in this instance), with the most recent data given the highest weight and the weights assigned to older data exhibiting exponential decay.

⁵ GARCH and ARCH terms, described later.

assess the volatility and implicit weighting of past growth patterns in ways that non-statistical techniques cannot. Moreover, these statistical techniques are predicated on assessments of their demonstrated forecast accuracy and can assess the risk associated with announcing or delaying future code openings at specific future dates. Non-statistical techniques offer no such assessments of forecast performance or appraisals of the risk incurred by timely business actions or the consequences of inaction.

The weekly, monthly and quarterly data sets used in this forecasting effort were each bifurcated into an estimation period and a hold-out period. The latter is used for model selection by testing and comparing the forecast accuracy of models calibrated using the same (or even different) estimation period(s). Use of a 30 month hold-out period is preferable since this corresponds to the announcement lead time for the toll-free industry to implement a new toll-free code.⁶

Various statistical model specifications were estimated with data from the estimation periods.⁷ The forecasts from these models were then compared to the actual TFN values for the corresponding common hold-out period. Better performing models were re-estimated using the full sample of data (through September 2012).

The candidate models were assessed on the basis of the following characteristics:

- 1) statistical significance of the modeled terms;
- 2) whether the resulting in-sample residuals appeared to be random (i.e., exhibited white noise);

⁶ Because insufficient time had passed since the 2010 code opening, the fall 2011 forecasting analysis relied on a hold-out period of only 18 months rather than 24 months. In spring 2012, sufficient time had elapsed to return to a 24-month hold-out sample. To conform more closely to the announcement lead time, the current analysis extends the hold-out sample to 30 months.

⁷ The specific data for the estimation period is determined by the length of the hold-out period. For example, with a 30-month hold-out period and monthly data, the hold-out period is April 2010 to September 2012, while the estimation period using the full historical sample is August 1997 to March 2010.

- 3) the principle of parsimony (the fewest terms employed to still fit the data and produce white noise);
- 4) the magnitude and nature of forecast errors in the hold-out period (Mean Percent Error (MPE), Mean Absolute Percent Error (MAPE), and Theil's measure of forecast bias);
- 5) the size of the confidence interval around the estimate;
- 6) robustness – whether the terms changed or their coefficients changed significantly when the models were re-estimated with the full data set; and,
- 7) whether the forecasts made sense, based upon our knowledge of TFNs.

As noted above, the business decision facing SMS/800 is when to start the planning and development effort required to open a new toll-free Numbering Plan Area (NPA). As an extension of the original base forecasting efforts, SMS/800 has expanded the focus to assess, more explicitly, the risk of exhaust over the relatively near-term (e.g., 2 year) period. These values are more germane to the business decision of starting the process to open a new toll-free NPA. This risk assessment utilizes information about the variance underlying the model forecasts (similar to the information used in creating a confidence interval around an estimate). This is described in more detail in a later section of the report.

The Data Set and Sample Period

Weekly historical data for TFNs in use are available starting in August 1997 through September 2012 (789 weeks in total).⁸ A monthly end-of-period TFN series was created by taking the last weekly value within each month starting in September 1997 (182 months). A quarterly end-of-period TFN series (61 quarters) was created by taking the last weekly value within the quarter beginning with third quarter 1997.

⁸ Several “gaps” in the weekly series prior to 2002 were filled in using a simple interpolation method. All data provided were assumed to be accurate. No cleansing of raw data was done to correct potential typos or other errors.

In the past, there had been some concern about sufficiency of sample size when using quarterly data. A statistical rule of thumb is to employ samples with 40 or more observations for ARIMA modeling. With a 30-month hold-out sample, the estimation sample when using end-of-period quarterly data is 51 quarters, and there are 61 quarters for the full-sample re-estimation. Even taking into account the effects of differencing and lagged terms, these samples are sufficiently large for the application of ARIMA analysis.

Statistical examination of the data series reveals a notable characteristic of the TFN series - the variation or fluctuation in TFNs over time.⁹ Specifically, the pre-2001 period is characterized by a much larger degree of variation in TFNs than the post-2001 period. Moreover, as seen in the table below, the variation across level data frequencies (i.e., weekly, monthly, quarterly) is essentially the same for each period examined.

		Coefficient of Variation			
		1997Q4 - 2000Q4	2001Q1 - 2003Q4	2004Q1 - 2012Q3	1997Q4 - 2012Q3
Weekly	Level	18.2%	3.5%	12.6%	17.8%
Monthly	Level	18.6%	3.7%	12.7%	18.0%
Quarterly	Level	19.3%	4.0%	12.9%	18.2%
Weekly	Difference	61.4%	-344.6%	253.8%	234.6%
Monthly	Difference	34.4%	-269.4%	148.8%	165.1%
Quarterly	Difference	23.6%	-233.8%	99.0%	138.7%

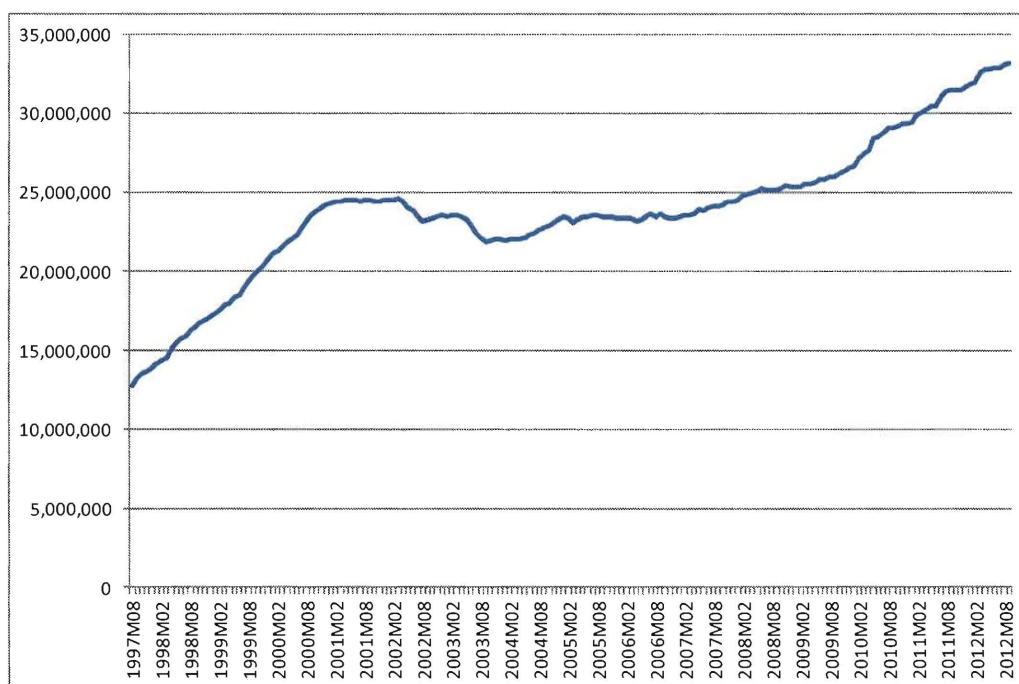
In contrast, when the three data series are transformed (from levels) into first differences to reflect TFN's incremental increase or decrease from one period to the next, these conclusions change. As shown in the table above, the degree of variation across the series differs by the periodicity of the data with the longer periodicity exhibiting lower variation (i.e., the first-differenced quarterly series exhibits the least variation across the

⁹ In statistical terms, TFN data are non-stationary, which suggests that it is more appropriate to model rates of change (i.e., first differences) rather than the level of TFN.

full sample, and the first-differenced weekly series exhibits the most variation across the full sample). Thus, models estimating the incremental change in TFNs are likely to perform better using monthly or quarterly data rather than the more volatile weekly data.

Also note that, regardless of the periodicity of the data, the post-2001 period exhibits a much higher degree of variation (in first differences) than the pre-2001 period (opposite of the pattern exhibited by the un-differenced, or levels, series). Differenced TFN shows greater variation after 2001, especially during 2001-2003, a period characterized by a general decline in the level of TFNs and several turning points. Yet, for differenced monthly and quarterly data, the 2004-2012 period has smaller variation than the corresponding full historical samples: 148.8% versus 165.1% for monthly and 99% versus 138.7% for quarterly.

One critical question is whether the entire period for which historical data exist is germane to the current forecast of TFN usage. As can be seen from the graph below and the coefficients of variation for first differences in the table above, the rate of growth of TFNs has varied considerably over the past 15 years.



The use of the full historical sample, while providing more data, means that first difference models are estimated across a data set in which the coefficient of variation in the data changes significantly across time periods; this has the potential to produce heteroskedasticity in the estimated residuals of the models. To address this issue, (i.e. to improve the statistical efficiency of the long-run forecasts) ARCH/GARCH terms¹⁰ are often employed in the modeling process.¹¹ Previous TFN forecasts have indicated that the introduction of ARCH/GARCH terms may improve the modeling of TFN time series.

An alternative approach is to estimate models over a more recent timeframe in which the growth of TFN usage is less variable, such as 2004-2012. As noted earlier, monthly and quarterly differenced data have less variation over this period than over the full historical sample. This property of the 2004-2012 sample may facilitate the development of more reliable forecasting models. While providing a more homogeneous path for TFN usage, however, such a truncated sample has fewer observations over which to estimate models; a smaller sample size can challenge model development. After developing models using the full sample and truncated sample, comparisons of forecast performance using a common 30-month hold-out sample can inform the choice as to which sampling strategy may produce better forecasting models.

Some acceleration in TFN growth may be caused by well-known documented events. For example, in 1998, 2000, and 2010 SMS/800 opened new toll-free NPAs. In 1998 and 2000, TFNs in use increased dramatically immediately after the code openings as Resp Orgs reserved numbers in the new prefix that were popular in previous prefixes. Prior to the 2010 code opening, the FCC established rules governing access to the new

¹⁰ An autoregressive conditional heteroskedasticity (ARCH) modeling term considers the variance of the current error term to be a function of the variances of the previous time periods' error terms. It is employed commonly in modeling financial time series that exhibit time-varying volatility clustering. If an autoregressive moving average model is assumed for the error variance, the model is a generalized autoregressive conditional heteroskedasticity (GARCH). See, e.g., http://en.wikipedia.org/wiki/Autoregressive_conditional_heteroskedasticity.

¹¹ GARCH addresses the residual variance in TFN still unexplained after the ARIMA modeling. For example, the weighted lagged squared residual represents "news" about the evolving variance.

prefix, limiting the quantity of TFNs each Resp Org could reserve per day. These rules may have modified the growth in TFNs immediately after the 2010 code opening. Nevertheless, an increase in the rate of TFN growth still occurred, but was less dramatic and spread over a longer adjustment period.

To accommodate such causative accelerations in TFN growth, the analysis tested for the inclusion of indicator variables that reflect the opening of new NPAs and the subsequent periods of adjustment in TFN growth¹². The periods associated with the two earlier code openings in 1998 and 2000 are included in the estimation samples using full historical data. The period associated with the 2010 code opening is included in the hold-out samples. Because the truncated samples beginning in late 2003 include no code openings in the estimation sample, no such indicator variables are tested in those models.

Model Estimation and Selection

SMS/800 examined many ARIMA models with varying data samples and specifications. Differenced data, both with log transformations and without, were examined for weekly data and for monthly and quarterly end-of-period data. ARCH and GARCH terms were also examined to assess their ability to improve hold-out sample performance. Several models produced relatively small errors (often less than 1% MAPE) for the 30-month hold-out period. Because several of the models produced similar statistical metrics (e.g., small absolute errors and low bias), other criteria guided the model selection process (as listed in the approach and methodology section above).

¹² The current analysis also examined the possibility of accelerations in TFN growth prior to code openings. Variables to address such accelerations were not uniformly significant and/or helpful to hold-out performance. Hence, these variables are not included in the forecasting models reported here.

Models Estimated Using the Full Historical Sample

Once the top candidate models had been selected, the models were re-estimated, using the full sample (with data through September 2012). The re-estimated models were evaluated again, adding consideration of robustness of the model terms, their estimated coefficients and the reasonableness of the forecast results.

Several models had acceptable statistical characteristics, including the list of candidate models in the table below: one estimated with quarterly data, one estimated with monthly data and one with weekly data.

	ARIMA(11,1,0) e	ARIMA(11,1,14))	LNARIMA(1,1,4)ARCH 1
Frequency	Week	Month	Quarter
Dep Var (TFN)	Non-Log	Non-Log	Log
Differencing	1x	1x	1x
Constant	Yes	Yes	Yes
AR Terms	1,2,4,7,9,11	1,2,11	1
MA Terms	0	3,14	4
ARCH Terms	0	0	1
GARCH Terms	0	0	0
30-Month MAPE	1.354%	0.574%	0.854%
30-Month MPE	-0.569%	-0.360%	-0.467%
Exhaust Date	March 2018	April 2018	2Q 2018
Date of 20% Risk	May 2014	January 2016	2Q 2015

The table above is illustrative of the “finalist” models using the full historical sample of TFN data.¹³ The auto-regressive (AR) coefficients in the models indicate that each of the

¹³ Only the weekly model incorporates indicator variables for code openings. For the weekly model, these variables are statistically significant and improve hold-out performance. Such variables were not statistically significant in the best monthly and quarterly models.

models relies heavily on the last several months of data to guide the forecast. Note that all of the models have reasonably low mean absolute percentage error (MAPE) for the 30-month hold-out period, and low percent bias (MPE), although the monthly and quarterly models perform better by this standard as expected. Further, the exhaust dates for the models are very similar, although the risk signatures indicate some differences in the modeling. The additional volatility in the weekly data noted above likely underlies the higher risk of the weekly model. Each of these models is reasonable based on the cited statistical criteria.

Note, however, that the MPE of each of the models is negative, indicating a tendency of all of these models to under-predict in the hold-out sample. Furthermore, close examination of the hold-out sample forecasts raises a specific concern. Ideally, when the forecasts in the hold-out sample diverge from actual TFN usage, there should be no clear pattern to the nature of the errors. Careful examination of the hold-out forecasts from the models above, however, shows that all of the models under-predict during the later months of the hold-out period. The performance of models at the end of the 30-month hold-out test is important because the business decision here values the reliability of models 30 months or more in the future much more than precision in the near term. MAPE and MPE weight all hold-out terms equally and do not focus on the longer forecast horizon. Final assessment of the long-term validity of the hold-out test is left to inspection by the analyst. The observation that the models above are under-predicting at long-term forecast horizons warns that these models may under-predict when extrapolated to forecast the exhaust date. Such under-prediction would result in exhaust dates that are too far in the future. That is, actual exhaust might occur earlier than expected. If SMS/800 were to rely solely on such forecasts, the announcement of a new code opening would occur later than appropriate. Because SMS/800 is a responsible steward of the TFN pool, such a forecast error is not consistent with conservative business decision-making regarding the timing of the announcement.

ARCH/GARCH terms were statistically significant only in the best quarterly model. Only the quarterly model employs a natural log transformation.

The deceleration of growth observed in the most recent TFN data had led SMS/800 to anticipate that the forecast exhaust point might be later than that of the April 2012 forecast. However, given the hold-out analysis cited above, moving out over two years appears unreasonable. Further analysis is warranted. An alternative approach is to evaluate models using shorter, truncated sampling.

Models Estimated Using a Truncated Sample

In previous studies, SMS/800 has evaluated the forecast performance of models estimated over shorter truncated samples relative to models estimated over the full historical sample. In general, past analyses have shown that models based on truncated samples tend to be more difficult to calibrate because sample sizes are much smaller. Also, such models have typically produced hold-out performance inferior to models estimated over the full historical sample. For these reasons, such models have not received any substantive attention in past reports.

As noted earlier, differenced monthly and quarterly data for the period 2004-2012 exhibit less variation than the corresponding full historical samples. Thus, models developed and estimated over that period may produce better forecast performance than models developed and estimated over the full historical sample. Because this period exhibits no turning points, however, models calibrated to this sample may miss turning points that might occur in the future.

SMS/800's earlier evaluations of truncated samples also reflected a concern with the limited number of observations available after the trough in TFN usage that occurs in late 2003. Currently however, even with the longer 30-month hold-out sample, the number of observations for monthly and quarterly data is now more amenable to statistical analysis. While one might define the trough as either October or December 2003, the analysis should err on the side of retaining the most observations in the sample. Thus, SMS/800 examines models estimated using data from October 2003 through September 2012.

The truncated estimation sample consists of 340 weekly observations, 78 monthly observations or 24 quarterly observations. The hold-out sample remains 130 weekly observations, 30 monthly observations or 10 quarterly observations—identical to the hold-out samples used to test models based on the samples beginning in August 1997. Thus, sample sizes using the truncated data are clearly adequate for weekly and monthly models and marginal for quarterly models. Certainly the 24 quarterly observations are adequate for regression or curve-fitting. 24 observations MAY be adequate for ARIMA analysis, though the relatively small number of observations may inhibit the statistical diagnostic tools that guide the specification of ARIMA models in the Box-Jenkins decision tree.

The table below illustrates the “finalist” models estimated using the truncated sample. No weekly model satisfied all criteria thus only monthly and quarterly models are reported. The models mimic and extrapolate the general pattern of accelerating growth after 2003. This acceleration of growth anticipates comparatively early exhaust in late 2014 or early 2015.¹⁴

	Time^2	TimeMA6	Time^2
Frequency	Month	Quarter	Quarter
Dep Var (TFN)	Non-Log	Non-Log	Non-log
Differencing	1x	1x	1x
Constant	Yes	Yes	Yes
AR Terms	0	0	0
MA Terms	0	6	0

¹⁴ Models that included trend terms (TIME) performed better in the truncated sample due to the rather consistent upward trend in TFNs since the trough in 2003. In fact, the best-performing models take the form of a regression of differenced TFN on Time squared as shown in the table above.

ARCH Terms	0	0	1
GARCH Terms	0	0	0
Other terms	Time squared	Time	Time squared
30-Month MAPE	1.39%	1.35%	1.37%
30-Month MPE	-1.14%	-0.98%	-0.95%
Exhaust Date	October 2014	1Q 2015	4Q 2014
Date of 20% Risk	August 2014	4Q 2014	3Q 2014

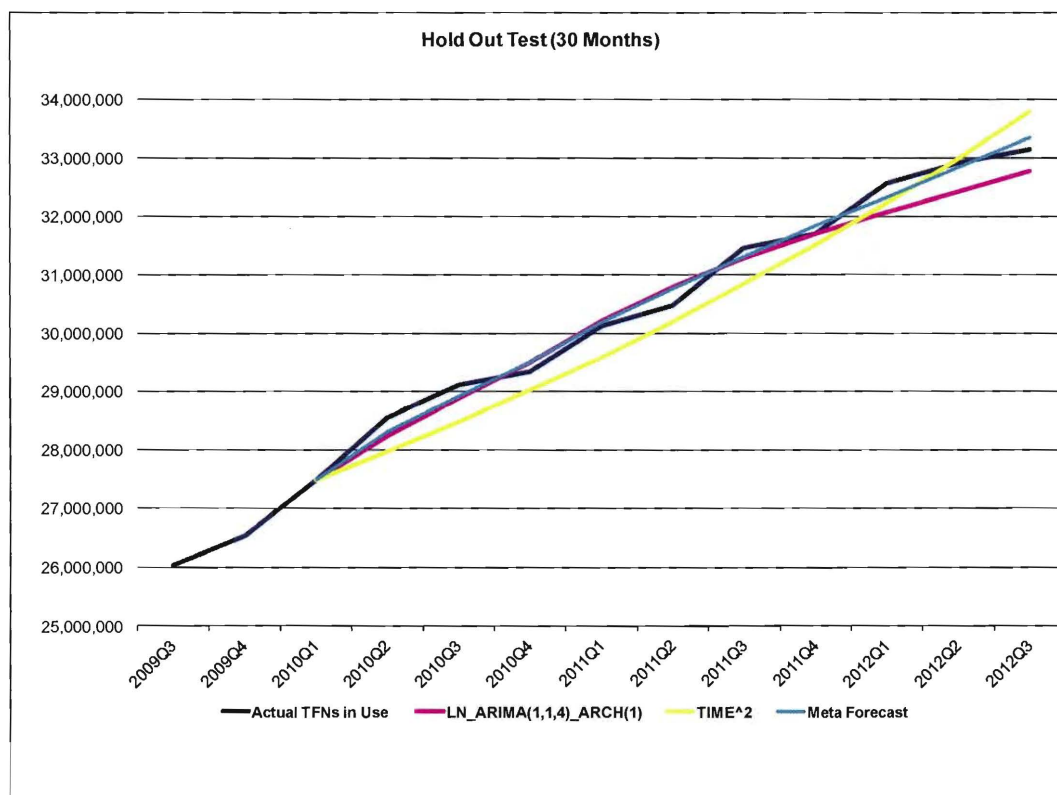
Note that the MAPE and MPE for these hold-out tests are not quite as good as those for the monthly and quarterly models estimated over the full historical sample. But investigation of hold-out results reveals that these models are over-predicting at the end of the hold-out period in contrast to the under-prediction of full-sample models. This raises the possibility that the two sets of models from the full and truncated samples might be complementary. If so, a combination or “meta”-model might provide forecasts superior to any of the individual models.

In the past, SMS/800 has relied on meta models when the statistical models were so close as to not be able to select a clear “winner.” In this case, meta-models are a good choice because the models, all with good statistical metrics, have very different patterns of performance in the hold-out sample as well as different exhaust date results. In past analyses, the approach to developing a meta-model was simply to average the results of each of the models. An alternative way is to use statistical analysis to derive a weighted average of the forecasts that best explains TFNs in the hold-out sample.¹⁵ Conducting such an analysis leads to weighting the forecast of the LN ARIMA quarterly full-sample model at approximately 65% and adding the forecast of the TIME^2 quarterly truncated

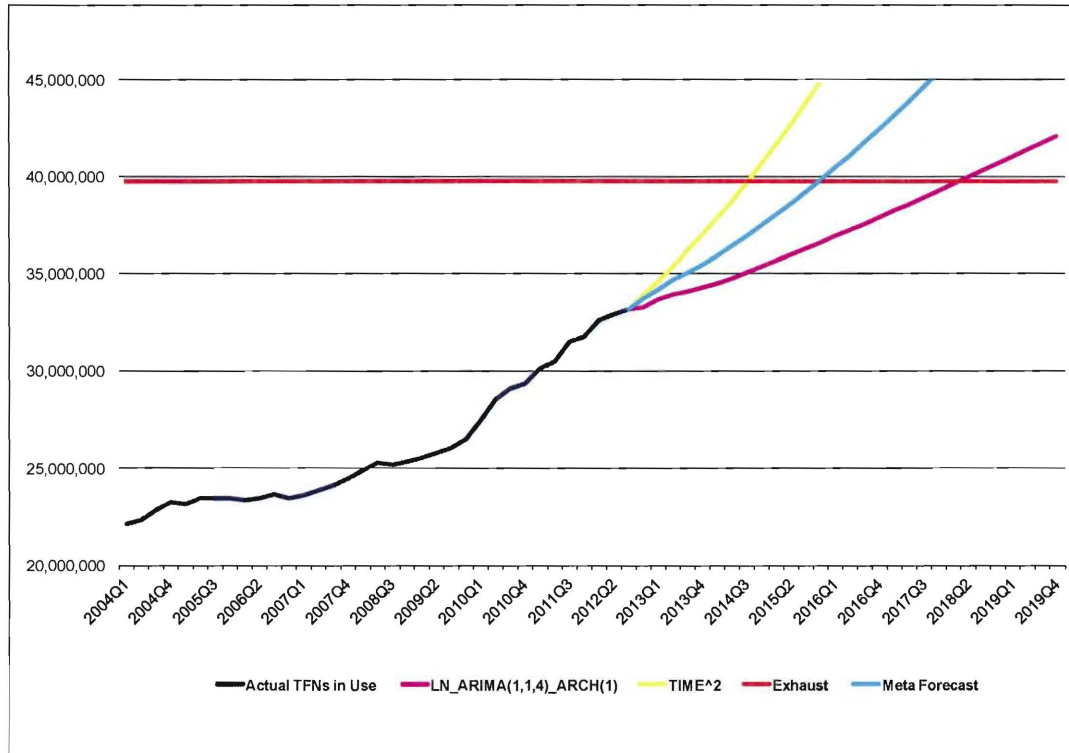
¹⁵ See J. Holton Wilson and Barry Keating, *Business Forecasting with ForecastX* (6th ed.), McGraw-Hill, 2009, 413-418, for a discussion of combining forecasts. The method proposed here is similar to that attributed to Charles R. Nelson. For additional detail regarding the specific meta-model used here, see *Forecasting Utilization of Toll-Free Numbers: Methodology*, October 2012.

sample model weighted at approximately 35%. The meta-model has a MAPE of only 0.56% with negligible MPE.

Most importantly, as demonstrated in the chart below, the meta-model hold-out results (in light blue) show no tendency to over- or under-predict actual TFNs (in dark blue), even at long forecast horizons. In contrast, the two models comprising the meta-model exhibit the biases described earlier. The full-sample model (in pink) under-predicts, especially late in the hold-out period, while the truncated-sample model (in yellow) over-predicts late in the hold-out period.



Forecasts from each of the two component models as well as the resulting meta-model are shown in the chart below.



As shown above, the meta-model forecast predicts exhaust of the currently available TFN pool during the fourth quarter of 2015. The following table also shows the period during which TFNs in Use is forecast to surpass 85%, 90% and 95% of the current TFN pool.

Spare % of TFN Pool	% of TFNs Remaining in Pool	TFNs in Use	Period When Reached
15%	85%	33,821,578	2013Q1
10%	90%	35,811,083	2014Q1
5%	95%	37,800,587	2015Q1
0%	100%	39,790,093	2015Q4

Although forecasting an exhaust date is helpful in determining when SMS/800 should announce a new code, it does not adequately convey the degree of risk and uncertainty (whether large or small and inherent in any forecast) as to when exhaust may occur.

Risk Assessment

As noted above, SMS/800 augments the point forecasts to assess the risk of exhausting the TFN number pool sooner than the date of the point forecast. These risk values are germane to the business decision of when to start the process to open a new toll-free code.

Specifically risk is defined here as the probability that TFN demand exceeds the stock of TFNs available under existing codes. For example, risk of 25% on a specific date suggests that there is a one in four chance that TFNs will exhaust by that date or 3:1 odds against exhaust. Risk of 50% on a specific date suggests there are even odds that any spare TFNs remain available. This is the most probable date of exhaust. After that date, the odds are higher than 1:1 that TFN demand will exceed the stock of available numbers.

The measure of risk relies upon the measure of the standard error of the forecasts and is conceptually similar to a confidence interval.¹⁶ Based on how the risk is calculated, a measure of risk cannot be developed for the meta-model. Thus, the risk measure for each of the models included in the meta-model is shown in the table below at quarterly intervals (from second quarter 2013).

Quarter	Exhaust Risk	
	TIME^2	LN ARIMA ARCH
2013Q3	0.000%	0.001%

¹⁶ Measured as, Risk = $1 - N((\text{Exhaust TFN} - \text{Forecast TFN})/\text{Forecast Standard Error})$ where N is the cumulative standard normal distribution.

2013Q4	0.001%	0.056%
2014Q1	0.418%	0.675%
2014Q2	9.3%	2.6%
2014Q3	44%	6%
2014Q4	Exhaust likely	10%
2015Q1	Exhaust likely	14%
2015Q2	Exhaust likely	18%
2015Q3	Exhaust likely	22%
2015Q4	Exhaust likely	25%
2016Q1	Exhaust likely	29%
2016Q2	Exhaust likely	32%
2016Q3	Exhaust likely	35%

Although the ARIMA model indicates the most likely date of exhaust is during the second quarter of 2018, the risk of exhaust rises to 25% within the next three years. The TIME^2 model's risk of exhaust exceeds 25% in less than two years, seemingly not that different from the ARIMA model. However, the escalation of risk is dramatically different rising from just over 9% in second quarter of 2014 to 44% by the end of the third quarter, while the ARIMA model is less than 3% in second quarter 2014, rising to just 6% in the third quarter of the same year.

Conclusions and Business Implications

The forecasts presented in this report confirm that **SMS/800 is within the 30-month window to exhaust and should consider proceeding with a recommendation that the FCC announce a schedule to open 844.**

Under the meta-model, TFNs in use:

- Reach exhaust in 2015Q4 => 30 months prior would be 2013Q1; and,
- Reach 90% exhaust in 2014Q1 => 30 months prior would be 2011Q3.

Under the most aggressive growth forecast (Time^2 using truncated sample), TFNs in use:

- Reach exhaust in 2014Q4 => 30 months prior would be 2012Q1.
- Conclusion: to permit an adequate preparation period, proceed to announce 844 code opening.

Even under the less aggressive growth forecast (LN ARIMA(1,1,4) ARCH(1)), TFNs in use:

- Reach exhaust in 2018Q2 => 30 months prior would be 2015Q4.
- Reach 90% exhaust in 2015Q2 => 30 months prior would be 2012Q4.

Further, volatility in growth rates suggests that the risk of exhaust rises during 2014-2015, within 30 months of the issue of this report. Again, conservative business practices would advise announcing soon the initiation of steps to open a new code.

Cautions and Recommendations

The statistical techniques used to develop these projections rely on the historical data and thus cannot predict turning points or dramatic changes in growth that are not implicit in the historical data. Thus, the forecasting exercise that SMS/800 has performed simply describes the most likely date that toll-free number capacity will be reached *if the data patterns of August 1997 through September 2012 should continue into the future.*

Appendix A – ATIS Approach to Determining an Exhaust Date for the TFN Pool

SMS/800 believes that statistical analyses, such as those described within the body of this report, are the most appropriate methods for projecting the exhaust of the TFN pool. Further, SMS/800 believes that statistical methods have the ability to assess risk surrounding the business decisions related to the exhaustion of the TFN pool, e.g., the risk that the TFN pool will exhaust sooner than the point estimate. However, the industry has historically relied on a method developed by ATIS to identify the date at which the industry should be notified of an impending code opening. This approach is described in the “Toll Free Resource Exhaust Relief Planning Guidelines” (ATIS-0300057), published in July 1998.

Exhaust of the TFN pool is determined by inputs for “average demand” and “accelerated demand” to be provided by SMS/800. The prescribed steps to determine the predicted number of months remaining until exhaust are represented by the following formula:

Spares – (Accelerated Demand * Quantity of Months of Accelerated Demand)

Average Demand

+ Quantity of Months of Accelerated Demand

The approach is appealing in that it is straightforward and simple calculation. However, as the inputs for “average demand” and “accelerated demand” are not well defined, the approach is prone to be arbitrary and can lead to highly volatile results based on different input choices. Further, there may not be an obvious rationale by which to choose among input values. However, it remains SMS/800’s understanding that the ATIS approach is the official method for determining when the toll-free industry should be notified of a code opening, and thus a version of the method was examined.

SMS/800’s variation on this approach relies upon more narrowly defined inputs, including:

- "Average demand" is defined as the average of all data points (within the sample size selected) within a range of the overall average plus and minus the standard deviation; and,
- "Accelerated demand" is defined as the average of all data points (within the sample size selected) greater than the overall average plus the standard deviation.

For the input related to the number of periods at accelerated demand, rather than simply inputting an arbitrary value, SMS/800's approach calculates how many times historical demand has exceeded the accelerated demand within the sample period. This percentage is then used within the revised formula below:

Spares

$$\text{(Average Demand * (1 - percent of periods above Accelerated Demand/100)) + (Accelerated Demand * percent of periods above Accelerated Demand/100))}$$

Examination of many alternatives using the ATIS approach led SMS/800 to report the following analysis using monthly and quarterly data, and to assess the results for many sample sizes. The tables below for monthly and quarterly samples are demonstrative of the results.

As with many analyses of data sets, the period over which the data are considered has a significant impact on the results. For the purposes of this exercise, SMS/800 examined the most recent four years of toll free number data, and based the ATIS approach on this data set. The following two tables represent the results based on the analyses performed on months and quarters.

# of Months in Sample	6	12	18	24	36	48
Spares	6,626,596	6,626,596	6,626,596	6,626,596	6,626,596	6,626,596
Average Demand	89,033	96,545	111,918	116,477	155,773	119,334
Acc Demand	252,325	625,874	624,160	581,155	588,863	552,946
%-age of periods at accel demand	17%	8%	11%	13%	14%	13%
Months to Exhaust	57.0	47.1	39.2	38.0	30.7	38.2
Exhaust Date	Jul-17	Sep-16	Jan-16	Nov-15	Apr-15	Dec-15

Figure A: ATIS Exhaust Approach - Months

# of Quarters in Sample	2	4	8	12	16	20
Spares	6,626,596	6,626,596	6,626,596	6,626,596	6,626,596	6,626,596
Average Demand	293,554	274,750	365,647	568,692	359,639	320,115
Acc Demand	1	863,622	928,881	1,004,813	969,515	932,851
%-age of periods at accel demand	0%	25%	25%	25%	25%	25%
Quarters to Exhaust	22.6	15.7	13.1	9.8	12.9	14.0
Exhaust Date	2Q2018	3Q2016	1Q2016	1Q2015	4Q2015	2Q2016

Figure B: ATIS Exhaust Approach - Quarters

As seen in figures A and B above, the ATIS approach indicates exhaust between:

- April 2015 and July 2017 with monthly data; and,
- March 2015 and May 2018 when relying on the quarterly data.